Changes in autopsy rates among cancer patients and their impact on cancer statistics from a public health point of view: a longitudinal study from 1980 to 2010 with data from Cancer Registry Zurich

Bieri, Uwe ; Moch, Holger ; Dehler, Silvia ; Korol, Dimitri ; Rohrmann, Sabine

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ORIGINAL ARTICLE

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Uwe Bieri · Holger Moch · Silvia Dehler · Dimitri Korol · Sabine Rohrmann

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Abstract During the last decades, autopsy rates have dramatically decreased in many countries. The Cancer Registry Zurich, which exists since 1980, provides the opportunity to address to what extent the number of autopsies in cancer patients has changed over a longer period of time and how often autopsies provide a diagnosis of clinically undetected cancer. Data from the Cancer Registry Zurich consisting of 102,434 cancer cases among 89,933 deceased patients between 1980 and 2010 were analyzed by means of descriptive statistics. The autopsy rate declined from 60 % in 1980 to 7 % in 2010. The total number of autopsies performed decreased from 1179 in 1986 to 220 in 2010. Furthermore, there was also a decline in the rate of newly detected tumours based on autopsy information. In 1980, the rate of newly detected tumours through autopsy was 42 % compared with 2010, when the rate had declined to 17 %. A consequence of the reduced autopsy rate is the reduction of incidental findings at autopsy in cancer registration. However, this reduction has not negatively affected the total incidence of cancer. It seems that the state-of-the-art diagnostic tools used for tumour detection are sufficiently reliable, allowing the scientific community to trust the quality of data provided by cancer registries in spite of decreasing autopsy rates.

Keywords Autopsy · Incidental findings · Cancer · Incidence · Registries · Switzerland

U. Bieri · S. Rohrmann (✉)
Division of Chronic Disease Epidemiology, Epidemiology, Biostatistics and Prevention Institute (EPBI), University of Zurich, Hirschengraben 84, 8001 Zürich, Switzerland
e-mail: sabine.rohrmann@uzh.ch

H. Moch
Institute of Surgical Pathology, University Hospital Zurich, Schmelzbergstr. 12, 8091 Zürich, Switzerland

S. Dehler · D. Korol
Cancer Registry Zurich and Zug, University Hospital Zurich, Zürich, Switzerland

Background

During the last decades, autopsy rates have dramatically decreased in frequency in Switzerland and many other countries [1–3], due to new legislation, increase in the number of imaging investigations [magnetic resonance imaging (MRI), computed tomography (CT), positron emission tomography (PET)] and tissue sampling. Many published studies [4–8] on this subject focused on the evolution of the diagnostic error rate.

The autopsy is an important quality tool in medical practice [9], in particular, to evaluate the reliability of cancer incidence. Burton et al. [4] investigated this topic and detected a significant discrepancy between clinical and autopsy diagnoses at a relatively high level, with a discordance rate of 44 %. They concluded that their findings were in accordance to previous studies investigating clinical-pathological discrepancies, similar as a more recent study from Grinberg et al. [5] and a study performed in an intensive care unit by Pastores et al. [8]. Lundberg [6] goes one step further, in stating that clinical-pathological discrepancies, not only restricted to tumours, increased over the years and even called it "the hard times of autopsy". However, a different picture emerges in the study by Schwanda-Burger et al. [7], who focused on two periods of time series between 1972 and 2002 in Switzerland and reported a significant reduction in diagnostic errors.

A study [10] conducted in Malmö, Sweden, reported a continuous decrease in the autopsy rate from 81 % in 1984 to 34 % in 1993. The conclusion was that the declining autopsy rate contributed to differences in the distribution of cause of death and cancer incidence.

The goal of this investigation is to answer the following key questions. Firstly, how has the number and rate of autopsies in cancer patients changed over a longer period of time? Secondly, to what extent does the autopsy provide additional information or a correction of the cancer diagnosis and how often does the autopsy provide a diagnosis of clinically undetected cancer? The Cancer Registry Zurich exists since 1980 and is the largest in Switzerland with more than 6000 incident invasive cancer cases per year. Thus, it provides the opportunity to analyze the impact of autopsy in verifying and optimizing cancer registry data over an extended period of time.

Methods

The cancer registry in the Canton of Zurich was established in accordance with a government decision in 1980. The aim was to cover all cancer cases emerging in the Canton of Zurich. With a population of around 1.3 million inhabitants and an annual accrual of more than 6000 new invasive cancer cases, the Cancer Registry Zurich is the largest cancer registry in Switzerland. In terms of organization, the registry is associated with the Institute of Clinical Pathology at the University Hospital Zurich and the Epidemiology, Biostatistics and Prevention Institute University of Zurich.

This study was based on the data collection of the Cancer Registry Zurich. In the time period from 1980 to 2010, 102,434 cancer cases diagnosed in 89,933 deceased patients were documented. A single cancer was diagnosed in 78,853 patients, and 11,080 patients were diagnosed with more than one cancer. If an individual was diagnosed with two or more different malignant tumours within this period, each individual tumour localization was included in the calculation of cancer prevalence, incidence and the comparison between incidence and the impact of autopsy on incidence. In calculating the overall autopsy number and rate, only, the first time, a tumour occurred was included.

The main basis for the acquisition of new cancer cases is pathology reports from public and private pathology and haematology institutions in the Canton of Zurich together with the information on Zurich cancer patients from cancer registries of other cantons. This information is supplemented by comparisons with hospital statistics, which are created by all hospitals nationwide for the Federal Office of Statistics. Information on autopsies was collected from pathology and forensic medicine institutes performing autopsies. Cancer cases in the Canton of Zurich are registered with presumed consent, and registration is based on a decision by the Zurich Government Council from 1980 and the general registry approval by the Federal Commission of Experts for professional secrecy in medical research from 1995. All data were used anonymously in this analysis, and no approval from the ethical committee of the Canton of Zurich was necessary.

Data are presented as absolute numbers or percentages. To examine the change in newly detected tumours through autopsies, we computed the percentage of incident tumours detected by autopsy as a 3-year moving average to smooth the observed changes. All statistical analyses were performed using Stata SE 12.

Results

In the Canton of Zurich, the autopsy rate among patients who died of cancer declined from 60 % in 1980 to 7 % in 2010 (Table 1). The total number of autopsies performed decreased from 1179 in 1986 to 220 in 2010.

In 1980, 426 autopsies were performed on men and only 254 on females. Even if these absolute numbers are related to the gender-specific differences in the number of autopsies performed, a remarkable gender-specific difference of almost 10 % emerges. Of all cancer-associated deaths in men in 1980, 64 % were autopsied, but this was the case in only 55 % of cancer deaths in women. This gender-associated difference in the autopsy rate decreased over time, to 7.3 % in men and 5.8 % in women in 2010.

To address the question to what extent autopsy provides additional information or a correction of the cancer diagnosis and to what extent the autopsy does provide a diagnosis of clinically undetected cancer, we examined the number of cancers detected based on an autopsy in relation to all autopsies on patients who died of cancer (Fig. 1). The number of autopsies performed on cancer patients reached a peak of 1179 in 1986. However, the number of newly detected tumours did not increase during this period. After 1986, the number of autopsies decreased, along with a decrease in tumours newly detected at autopsy. To better understand this development, we examined the change in the number of newly detected tumours by means of an autopsy as a percentage of the incident cases at the level of individual tumour entities (Fig. 2). The analysis focused on tumour entities for which autopsy information contributed at least 15 % to the incidence rate at the beginning of data collection and for which the tumour-specific trend was in accordance with the overall trend (for the latter reason, neoplasms of the small intestine and larynx were excluded). These criteria were met by five tumour entities: liver, gallbladder and biliary tracts, pancreas, prostate, thyroid gland and kidney. In 1980, the discovery rate at autopsy for these five entities was about 15 %, which then more or less steadily decreased to less than 3 % in 2010. This, however, did not affect the actual number of cases diagnosed during this time period (Fig. 3).

Table 1 Overview about the cancer related autopsies from 1980 to 2010

Year	Cancer deaths	Autopsy performed	Autopsy performed in %	Cancer deaths in men	Autopsy in men	Autopsy in men in % related to all male patients	Cancer deaths in female	Autopsy in women	Autopsy in women in % related to all female patients
1980	1127	680	60.34	663	426	64.25	464	254	54.74
1981	1802	871	48.34	1068	538	50.37	734	333	45.37
1982	2144	965	45.01	1209	567	46.90	935	398	42.57
1983	2422	1023	42.24	1380	618	44.78	1042	405	38.87
1984	2520	1032	40.95	1386	607	43.80	1134	425	37.48
1985	2623	1127	42.97	1494	672	44.98	1129	455	40.30
1986	2711	1179	43.49	1537	716	46.58	1174	463	39.44
1987	2857	1084	37.94	1571	617	39.27	1286	467	36.31
1988	2911	1051	36.10	1629	606	37.20	1282	445	34.71
1989	2981	1127	37.81	1697	682	40.19	1284	445	34.66
1990	2981	1014	34.02	1689	600	35.52	1292	414	32.04
1991	2996	949	31.68	1662	559	33.63	1334	390	29.24
1992	3070	975	31.76	1715	548	31.95	1355	427	31.51
1993	3039	793	26.09	1663	466	28.02	1376	327	23.76
1994	3009	675	22.43	1640	378	23.05	1369	297	21.69
1995	2859	647	22.63	1568	415	26.47	1291	232	17.97
1996	2778	642	23.11	1518	392	25.82	1260	250	19.84
1997	3329	627	18.83	1817	372	20.47	1512	255	16.87
1998	3258	584	17.93	1813	369	20.35	1445	215	14.88
1999	3153	574	18.20	1767	356	20.15	1386	218	15.73
2000	3139	499	15.90	1687	289	17.13	1452	210	14.46
2001	3088	451	14.60	1685	271	16.08	1403	180	12.83
2002	3077	461	14.98	1666	274	16.45	1411	187	13.25
2003	3157	364	11.53	1748	215	12.30	1409	149	10.57
2004	3213	361	11.24	1734	224	12.92	1479	137	9.26
2005	3330	339	10.18	1840	207	11.25	1490	132	8.86
2006	3215	317	9.86	1778	210	11.81	1437	107	7.45
2007	3331	274	8.23	1788	171	9.56	1543	103	6.68
2008	3200	230	7.19	1785	151	8.46	1415	79	5.58
2009	3286	218	6.63	1762	140	7.95	1524	78	5.12
2010	3327	220	6.61	1860	135	7.26	1467	85	5.79

The total number of autopsies performed broken down by sex and the proportion of the total number of autopsies performed broken down by gender from 1980 to 2010. Each patient occurs only once, regardless of whether the patient was initially attributed to one or more tumour diagnoses

Discussion

Our data support the global trend in declining autopsy rates and total number of autopsies performed [1]. In 30 years, the rate of autopsies performed on patients, who died of cancer, declined from 60 % in 1980 to 7 % in 2010. This decrease is even more significant than the decline of the overall autopsy rate in Switzerland from 13 % in 1993 to < 4 % in 2012 indicated by a recent publication [11]. A variety of causes can be considered for the continuously decreasing autopsy rates. On the one hand, scientific progress along with the introduction of new diagnostic tools allows to detect cancer with a high reliability; on the other hand, changes in legislation have had an important impact. Chariot et al. [12] conclude that the introduction of a new bioethics law in 1994 contributed markedly to the decline of the autopsy rate. In Zurich, a legal change occurred in 2005 in the procedure for obtaining permission to perform an autopsy, but our results indicate that the decrease in the number of autopsies performed started much earlier and this legal change did not significantly change the trend in declining autopsy rates in the following years. Another possible reason is where patients die, for which a study [10] from Malmö, Sweden, provides evidence. This retrospective study investigated causes and consequences of the decline with a specific focus on cancer incidence. It

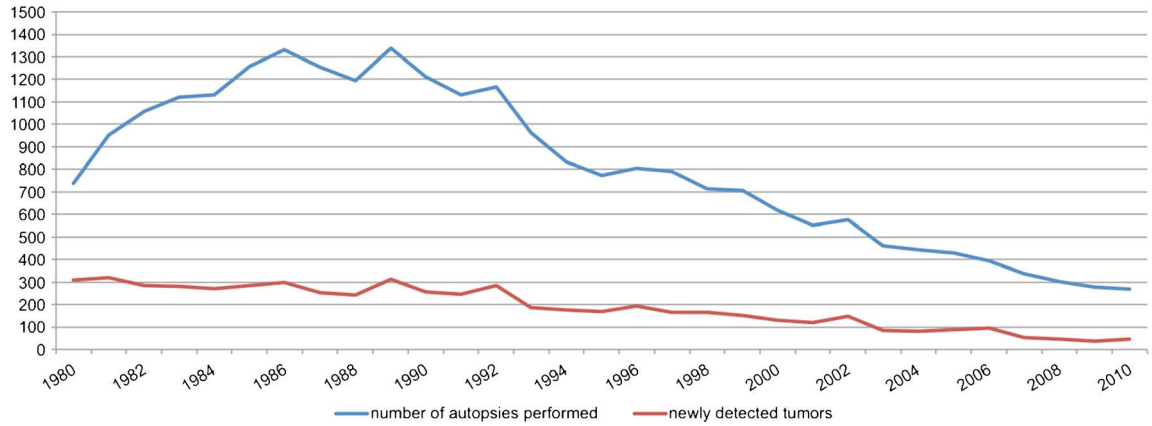

Fig. 1 Newly detected tumours related to the total number of autopsies performed from 1980 to 2010. *y-axis* number, *x-axis* year

provides a useful reference point for our own analysis because of the comparable framework with regard to socioeconomic structures. Their results indicate that patients who died in a nursing home less often underwent an autopsy than patients who died in a hospital. In Malmö, the percentage of people dying in nursing homes increased between 1984 and 1993 from 1 to 29 %. This development mirrors the declining autopsy rate in Malmö. The authors conclude that this change in where patients die is the most important explanation of the declining autopsy rate in Malmö. This is also the conclusion of a US study [13]. Since we were more focused on the consequences than on the causes of the declining autopsy rate, we did not investigate this as a possible explanation for the decline. However, most citizens of Zurich died in hospitals and nursing homes in 2010 [14]. Based on the similarities in socioeconomic structures between Sweden and Switzerland, it is likely that this observation explains a part of the decrease in autopsy rate in our study.

Only three studies [15–17] that investigated gender differences in autopsy rate have been published. These studies indicate that there is a difference by sex, i.e. a higher autopsy rate in men than in women, but they were not able to identify possible causes for this difference. However, these studies describe gender selection trends in autopsy not limited to cancer cases, but for the whole spectrum of fatal medical conditions.

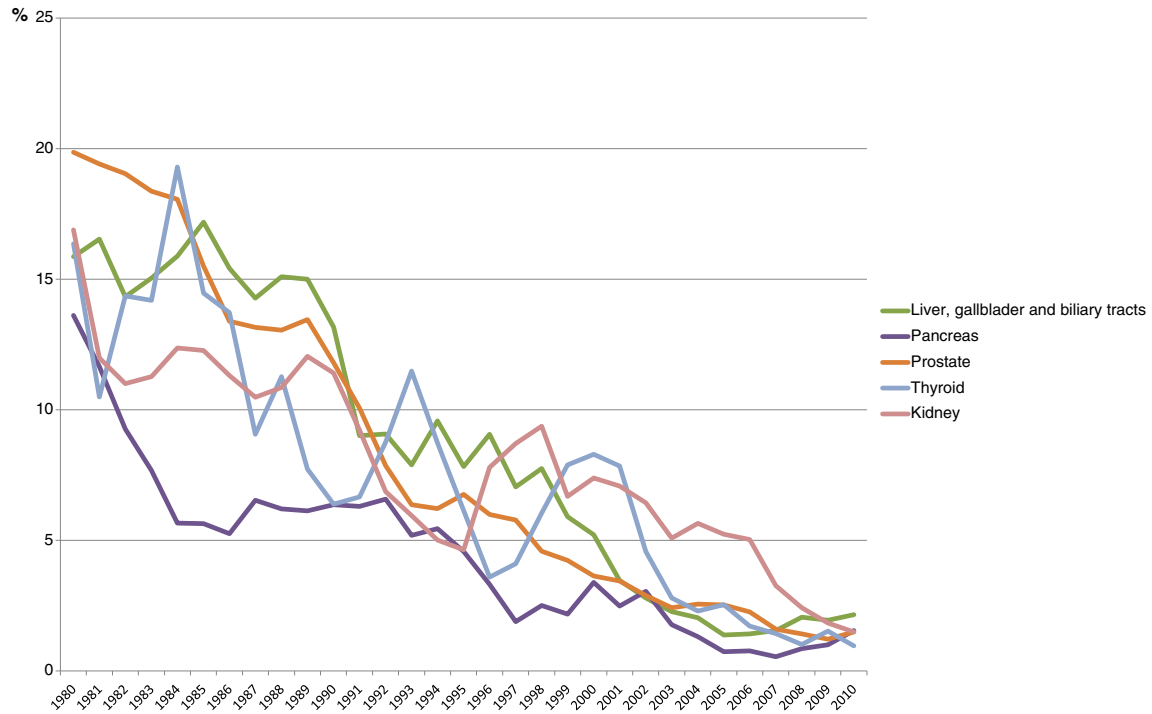

Fig. 2 The development of the initial detection rate for tumour entities for which the autopsy was in the beginning of the data collection of a certain relevance for the incidence. Summarized with "moving averages of 3 years" with the aim of enhancing the clarity of the figure. *y-axis* incidence share of the autopsy in percentage, *x-axis* year

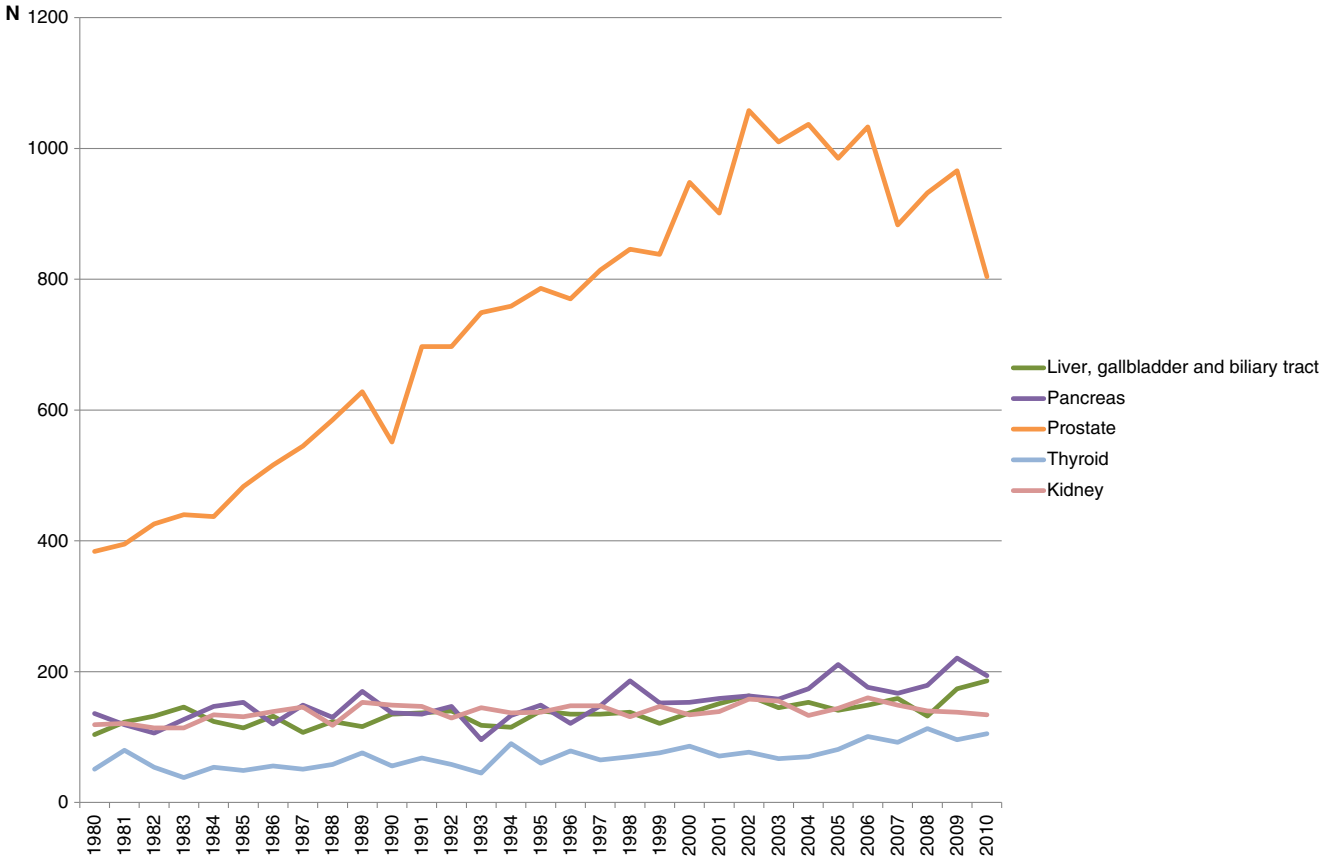

Fig. 3 The development of total incident cancer cases for tumour entities for which the autopsy was in the beginning of the data collection of a certain relevance for the incidence. *y-axis* incidence, *x-axis* year. Under-registration of prostate cancer due to limited access to two pathology institutes (4–10 %) occurred between 2007 and 2010

Kircher et al. [15] observed that non-white men who died at 20 to 29 years of age were the most likely group to undergo an autopsy. The autopsy rate was not proportional to the major categories of the underlying cause of death. Deaths due to trauma accounted for a larger proportion of all autopsies (25 %) than of all deaths (6 %), and this difference was even called the "epidemiological distortion factor: trauma associated death" by the authors [15]. Since we focused our study on cancer-associated deaths, we cannot transfer this approach to our data. In order to find convincing explanations for this phenomenon, further and more specific investigations targeting the discrepant autopsy rates associated with sex are required.

We examined whether the decline in autopsy rates affected the number of newly detected cancers and cancer rates in general. We indeed observed a reduction in cancer cases detected by autopsy of the tumour entities for which at least 15 % of cases had been detected by autopsy at the beginning of the observation period (liver/gallbladder/biliary tract, pancreas, prostate, thyroid gland, kidney). Lindström et al. [10] argued that a reduced autopsy rate might lead to a reduction of incidental findings at autopsy, which in turn might affect the incidence of several types of cancer. He based this on a comparison of the seven tumour sites (stomach, small intestine, biliary tract and liver, prostate, nervous system, thyroid gland and endocrine glands) for which incidental findings at autopsy contributed to more than 20 % of the incidence in 1984. The decline in autopsy rate was associated with a decline in the number of cases for six of these seven entities. Our results, based on changes in the incidence of the cancer entities for which autopsies provided about 15 % of cases, only partly confirm the results of the Malmö study. In the Canton of Zurich, the incidence of prostate cancer increased considerably in the past 30 years, whereas the incidence of the other tumour entities, for which autopsies contributed considerably to the incidence rate, remained stable or did not decrease markedly during the past 30 years (see Fig. 3 and [18]). A possible explanation for this phenomenon is the emergence of the PSA test in the early 1990s, which leads worldwide to an increase in prostate cancer incidence [19]. The impact of PSA testing on the detection rate of prostate cancer at autopsy was investigated in a study by Konety et al. [20]. Their findings indicate that compared with the pre-PSA era, the prevalence of latent cancers only detected at autopsy had significantly decreased. The cancers only detected by autopsy in the pre-PSA era were found to be grossly invading adjacent structures (22 %), while none of the latent prostate cancers found in

the PSA era were found to extend grossly beyond the prostate. This can partly be attributed to different patient populations, but most of all, to different methods of tissue sampling. The rate of prostate cancer in the pre-PSA era was highest in studies in which the whole prostate was cut in serial sections. The frequency of prostate cancer was clearly lower in studies in which only one or a few prostate sections were histologically examined at autopsy. Scott et al. [21] showed that serial sectioning of the whole prostate can double the number of detected prostate cancers as compared to routine procedures. This suggests that a considerable number of microscopic carcinomas remain undetected in routine autopsy series. A similar phenomenon can be attributed to our findings of thyroid cancer, because the thyroid is not completely embedded to search for small papillary cancers.

Long-term trends differed between men and women with increasing age-adjusted incidence rates of liver, thyroid and pancreatic cancer among women, but not men. Thus, it appears that decreasing autopsy rates were only of marginal influence on cancer incidence rates. Rather, new sophisticated diagnostic tools appear to contribute to increased detection and diagnosis even in the context of decreasing autopsy rates. On this basis, we conclude that the incidence data for the Cancer Registry Zurich is a reliable reference for social, economic and political purposes. Despite the fact that the quality of our data was probably not severely affected by the declining autopsy rate, the autopsy is still the only tool that provides absolute certainty about the true nature of death, because it is the reference mark for all upstream diagnostic measures.

The strength of our study is the long-standing data collection of the cancer registry in the Canton of Zurich and the large number of cases. Data quality of the Cancer Registry Zurich is considered to be good according to the rates of cases known by death certificate only (DCO), which were always below 5 % during the years 2000 to 2010, and the proportions of histologically verified cancer cases, which varied between 92 and 96 % during the years 2000 to 2010. This means that these quality markers were always below, respectively, within the internationally defined limits.

Despite this strength, some limitations of our database have to be mentioned. On the one hand, for resource reasons and limited access to data, it is not known for all deaths whether an autopsy had been performed or not (10,208 cancer deaths). This affects, in particular, the 1990s and the year 2006. However, the percentage of newly detected tumours was similar in these years compared with the other years. On the other hand, only minimal information about the autopsy results was available in some cases. These cases were labelled as "autopsy was performed, but no further information available" ["Autopsie vorhanden, NNB"]. Of the 89,933 cancer deaths, 13,875 fall into this category. This, however, does not affect our results because in case a tumour is detected during autopsy, this case will be reported to the cancer registry anyhow.

Our data do not allow us to address the question which methods were used to diagnose a tumour in our series of patients. However, in data from 1972, 1982, 1992 and 2002, a significant increase in the number of diagnostic procedures used including CT investigations, biopsies and fine-needle aspirations, is clearly documented in a study conducted to examine discrepancies between clinical and autopsy diagnoses in the University Hospital Zurich [7]. This study showed that the increased use of modern investigation techniques was associated with significantly increased sensitivity and accuracy of the diagnosis of cancer.

In conclusion, our study confirms the global trend towards decreasing autopsy rates. A consequence of this development is a reduction in the frequency of an incidental finding of cancer at autopsy. In contrast to a previous study from Sweden [10], this does not appear to have a negative impact on the incidence of cancer in our statistical investigations. In spite of decreasing autopsy rates, the quality of cancer registries is solid. Nonetheless, autopsies remain to be an important measure to ensure the reliability of mortality statistics and the correct classification of the cause of death. A continuing decrease in autopsy rates might result in failure to detect homicide [22]. Furthermore, the autopsy remains to be the gold standard in terms of quality control for diagnosis [3] and an important tool for the education of medical students [23].

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Conflict of interest None.

Author's contributions UB performed the statistical analysis and drafted the manuscript. HM, SD and SR participated in the design of the study. SD and DK coordinated the study and were responsible for data collection and preparation. All authors proofread the manuscript critically and approved the final manuscript.

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